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Original research article

EFFECTS OF MEDICINE BALL TRAINING ON PHYSICAL FITNESS IN PRIMARY SCHOOL CHILDREN

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Abstract. *Medicine balls provide an effective means of improving muscular power, endurance and functional fitness. The aim of this research was to determine the effects of medicine ball training on physical fitness in primary school children. A total of 60 (26 girls) primary school children aged 10-12 voluntarily participated in this study. The physical fitness of the children was estimated by the following tests: standing broad jump, vertical jump, bent-arm hang, sit-ups, push ups, medicine ball tests. The experimental group had twice per week medicine ball training on nonconsecutive days for 12 weeks under monitored conditions in school. Compared with the initial testing, there was a significant (p<0.05) improvement in both jump tests. In the medicine ball tests the ANOVA revealed a statistically significant difference between groups pre- to post-training (p<0.05) in Backward Overhead Medicine Ball Throw. There were significant differences (p<0.05) between the initial and final testing for the flexed arm hang, push ups and sit ups in both groups. Findings from the present study indicate that medicine ball training instructed by qualified professionals can result in significant improvements in selected physical fitness components in children, and is a costeffective and time efficient method for promoting physical activity in school-based programs.*

Key words: *exercise, physical education, impact, fitness*

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INTRODUCTION

Physical activity is related to numerous benefits and has the potential to improve the quality of life for school children (Naylor & McKay, 2009; Ortega, Ruiz, Castillo, & Sjostrom, 2008). Moreover, physical fitness during childhood has been identified as a strong predictor of current and future health status (Smith et al., 2014). However, the usual school day lasts 8–9 hours and in most cases, a great amount of this time is composed of sedentary activities. In addition to the hours spent in school, children in numerous countries spend almost half of each calendar year in school. Therefore, schools are responsible for a large amount of the children's time and have the potential to provide children an opportunity to fulfill their daily physical activity needs (Janssen & Leblanc, 2010).

The importance of improving the physical fitness of children has prompted the development of novel and creative approaches that provide an opportunity for all children to participate in regular, healthful physical activity (Faigenbaum & Mediate, 2006). While children have traditionally been encouraged to participate in aerobic activities such as jogging and swimming, a compelling body of scientific evidence supports participation in appropriately designed youth resistance training programmes that are supervised and instructed by qualified professionals (Lloyd et al., 2014). Additionally, the aforementioned authors stated that youth who do not participate in activities that enhance muscle strength and motor skills early in life may be at increased risk for negative health outcomes later in life.

Whereas different modes of resistance training such as weight machines and free weights have proven to be safe and effective for children, medicine balls have become very popular in schools, fitness centers, and sport training facilities (Faigenbaum & Mediate, 2008). One of the most important benefits of medicine ball training is that it conditions the full body instead of separate parts. In general, 140 to 160 beats per minute is the average heart rate response to medicine ball training (Faigenbaum & Mediate, 2006). It was reported that resistance training with medicine balls can be an effective method of conditioning for school age youth during physical education (Faigenbaum & Mediate, 2006). However, one other study showed that untrained boys and girls (8 years old) who trained twice per week for 8 weeks using child-sized medicine balls, did not demonstrated significant improvements in 1RM chest press strength as compared with the control group (Faigenbaum et al., 2007). Obviously, more school-based interventions concerning medicine ball training are needed.

While enjoyment in physical education classes and improvement in motor skill ability are the most important outcomes of children in physical education, the amount of time during which children are engaged in moderate and vigorous physical activity is also important for the quality of physical education. Medicine balls provide a unique type of resistance that can be used for an unlimited number of exercises that can be performed at different movement speeds. Therefore, the aim of this research was to determine the effects of medicine ball training on physical fitness in primary school children.

METHODS

Participants

A total of 60 (26 girls) primary school children aged 10-12 voluntarily participated in this study. The children's characteristics are presented in Table 1. Prior to the enrolment in the study, parents reported their child's health history and current activity status through a questionnaire and only healthy, active children from 10 to 12 years old were chosen. All the children had the same two classes per week and were not involved in additional strenuous training during this study. Participants were excluded if they had a chronic pediatric disease or had an orthopedic condition that would limit their ability to perform exercises. Participants were excluded if they had missed two consecutive classes for the duration of the study. The study was approved by the Research Ethics Committee of the Faculty of Sport and Physical Education in Niš, and written informed consent was obtained from both parents and children.

Table 1 Basic anthropometric characteristics of the study participants; Values are means (±SD)

	Age (y)	Body height (cm)	Body weight (kg)	BMI(kg/m^2)
Experimental group (30)	11.6±1.01	152.75±7.78	46.16±11.50	19.59±3.46
Control group (30)	11.4± 1.2	151.99±7.18	48.06±12.78	20.67±4.84

Procedures

Children's anthropometric and fitness measurements were performed early in the morning, after at least 12 h of fasting and 24 h from the last high-intensity exercise effort. All measurements were repeated at the same time of day as close as possible to the resting condition. Measurements were taken in early-October (a month after the beginning of the school year) and in late December. All study procedures took place at a school athletic facility. The same researchers tested and trained the same participants and the fitness tests were performed in the same order with identical equipment, positioning, and technique. All of the participants took part in one introductory session during which time proper form and technique on each fitness test were reviewed and practiced. During this session, research assistants demonstrated proper testing procedures and participants practiced each test. After the training program, the participants were instructed to perform the tests in the same order as they did before the training program.

Participants were asked not to perform any vigorous physical activity the day before or the day of any study procedure. Height was measured on a wall-mounted stadiometer to the nearest 0.5 cm. Weight was measured on a calibrated beam balance platform scale to the nearest 0.1 kg. Before each testing, the participants performed a standard 20-minute warm-up. The standard warm up protocol consisted of 10 min of warm up running and 10 min of dynamic stretching and 5 x 30m of running exercises.

Physical fitness of children was estimated by the following tests: standing broad jump, vertical jump, bent-arm hang, sit-ups, push ups, medicine ball tests. Most of the tests are briefly described in Bala, Krneta, & Katić (2010).

- *Sit-ups with crossed arms*: The participant lies on his back, knees bent, arms crossed on the chest, and performs sit-ups, feet held fast by an assistant. The number of correctly executed sit-ups in 60 s is recorded.
- *Bent-arm hang*: The participant grips the bar, fingers on top and thumb underneath, pulls up (chin above the bar) and holds the position as long as possible without resting the chin on the bar. Time is measured in 0.1-s units.
- *Push Ups*: The participant assumes a prone position on the floor with hands placed under or slightly wider than the shoulders, fingers stretched out, legs straight and slightly apart, and toes tucked under. The participant pushes up off the floor with his arms until his elbows are straight while keeping the legs and back straight. The back should be kept in a straight line from head to toes throughout the test. Then, the

participant lowers his body using the arms until the elbows bent at a 90° angle and the upper arms are parallel to the floor. This movement is repeated as many times as possible, finishing when the participant stops, when the participant does not perform the push up completely or when the participant does not maintain the right position. This test assesses upper-body muscular endurance (Castro-Piñero et al., 2009).

- *Standing broad jump*: The participant jumps with both feet from the reversed side of Reuter's bounce board onto a carpet with scale. The jumping distance (in cm) is recorded.
- *Vertical jump* (VJ): For the standing reach, while wearing their normal footwear, children were requested to stand with their feet flat on the ground, extend their arm and hand, and mark the standing reach height while standing at a 90° to a wall. Children were encouraged to fully extend their dominant arm to displace the highest vane possible to determine their maximum standing reach height. The measurement of the standing reach height allowed for a calculation of the relative jump heights on each of the jumping tasks (absolute jump height (cm) – standing reach height (cm) = relative jump height) (Sheppard, Gabbett, & Reeberg Stanganelli, 2009). Jumps were measured using a basketball backboard marked with lines 1 cm apart. Vertical jumps started from a standing position with the hands at shoulder level and arms raised from the start position without an extra swing. All of the tests were invigilated by the same observer who was situated on chair placed 2 m from the backboard. Jumps were recorded as the best of 3 attempts (Stanganelli, Dourado, Oncken, Mançan, & da Costa, 2008).

Medicine Ball Tests

Upper-body explosive strength was estimated using an overhead medicine ball throw, seated medicine ball throw and lying medicine ball throw. Medicine ball throws were performed using the 2-kg rubber medicine balls (Tigar, Pirot, Serbia). All of the participants were introduced to the testing during a familiarization session. The skin of the medicine ball was lightly dampened (magnesium carbonate) to leave an imprint on the floor where first contact was made and to ensure precise measurement of the throwing distance. Distance was measured from the base of the bench to the closest edge of the medicine ball imprint.

- *Backward Overhead Medicine Ball Throw (BOMBT):* The athlete holds a medicine ball with arms straight in front of the body and, following a countermovement, flexes at the hips and knees before extending forcefully backward to throw the ball over the head.
- *Overhead medicine ball throw (MEDS):* The test was conducted with players standing one step behind a line marked on the ground facing the throwing direction, with a 3-kg medicine ball held in both hands behind the head. Players were instructed to plant the front foot with the toe behind the line and to throw the medicine ball overhead as far forward as possible. Each throw was measured from inside the line, to the nearest mark made by the fall of the medicine ball. Throwing distance was measured to the nearest 1 cm, with the greatest value obtained from 3 trials used as the overhead throw score (Gabbett & Georgieff, 2007).
- *Lying medicine ball throw (MEDL):* The participants were instruct to lay down on their backs and held a 3-kg medicine ball on the floor above their head with the arms fully extended. The shoulders were on the zero-line. The throwing action was similar

to that used for a soccer throw-in. The ball was thrown forward as vigorously as possible, while the head was kept on the floor. The best of the consecutive trials was recorded as the final result (to the nearest 1 cm) (Tomljanovic, Spasic, Gabrilo, Uljevic, & Foretic, 2011).

Training program

Table 2 PE class and Medicine ball training

PE class	Experimental program
▪ warm up	▪ warm up
▪ PE unit	▪ PE unit
▪ drills	▪ medicine ball exercise
▪ cool down	▪ medicine ball games (additional challenges)
	▪ cool down

The experimental group had twice per week medicine ball training on nonconsecutive days for 12 weeks under monitored conditions. A physical fitness specialist discussed and demonstrated proper medicine ball training procedures during one week, and children had an opportunity to ask questions. The duration of the medicine ball exercise was recorded, with session typically lasting 15-20 minutes. Besides these sessions, usual physical education classes were performed. Each class consisted of a warm-up period (5-8 minutes), medicine ball training (10 – 15 min) and PE unit phase (15 to 20 minutes), following 5 minutes of cool down. During the warm-up period the participants performed a series of six to ten low to moderate intensity exercises with a 1-2 kg leather medicine ball. During the medicine ball phase, the participants performed a variety of medicine ball exercises that progressed from simple to complex as their competence and confidence improved. The various medicine ball conditioning exercises included: lower body (e.g., underhand squat, over and behind head throw), upper body (e.g., shoulder press, medicine ball slams and throws), stability (e.g., single leg toss), reaction (e.g., wall chest pass). Most medicine ball exercises involved lifting and throwing. Within each category, the exercises progress from the least challenging to the most challenging. Level one and level two exercises are the easiest to perform, whereas level five and level six exercises are the most complex and are specifically designed to elicit maximum muscle fiber recruitment while challenging cognitive abilities (Faigenbaum & Mediate, 2006). A summary of the medicine ball training program is in Table 3.

Table 3 Medicine ball games training program between week 1 and week 12.

	Medicine ball games guidelines		
	Week 1-4	Week 5-8	Week 9-12
Load	1 kg	2 kg	2 kg
No. exercise	2-4	2-4	3-5
No. reps per game	10-20	12-25	12-25
Rest interval	2-3 min	2-3 min	2-3 min
Frequency	2 x per week	2 x per week	2 x per week

The participants in the control group did not perform a specific program but attended their regular PE class twice per week during the study period and participated in the same traditional PE activities under the guidance of a PE teacher.

Statistical analysis

Descriptive data were calculated for all the variables. Group differences at baseline were evaluated using independent sample t-tests. Normality assumptions for all data before and after the intervention were checked respectively with Kolmogorov–Smirnov tests. A two-way repeated measure ANOVA (2 × 2) was used to test for interactions and main effects for time (initial vs. final) and group (experimental vs. control) on the dependent physical fitness variables. Statistical analyses were conducted in SPSS (SPSS, Version 18.0, Chicago; IL). Statistical significance was established a priori at $p < 0.05$ to test the hypothesis that the experimental group would be more effective than the control in improving physical fitness measures in children.

RESULTS

The Kolmogorov-Smirnov test has shown that data were normally distributed. An independent sample t test revealed no statistically significant differences between the groups for all variables prior to the training. Compared with pretraining, there was a significant ($p < 0.05$) improvement in both jump tests (Table 4). However, the group that participated in the medicine ball training program made significantly greater gains compared to the control group ($p < 0.05$).

In the medicine ball tests, the ANOVA revealed a statistically significant difference between groups pre- to post-training ($p < 0.05$) in BOMBT. There were no significant differences ($p > 0.05$) between the initial and final testing for the overhead medicine ball throw in the control group (Table 4).

Table 4 Mean ± SD results of different parameters: strength, jumping, and throwing performance before the experimental period (initial) and after the 12-week experimental period (final).

	Experimental group			Control group		
	Initial (Mean ± SD)	Final (Mean ± SD)	EF	Initial (Mean ± SD)	Final (Mean ± SD)	EF
VJ	30.29±4.65	36.16± 6.59*†	1.029	32.88± 3.09	35.57± 4.08*	0.743
SBJ	136.65±20.68	145.56± 20.56*†	0.432	136.66± 19.48	140.70± 17.59*	0.217
MEDL	4.56± 0.72	5.02± 0.65*	0.670	4.40± 0.69	4.61± 0.65*	0.313
MEDS	6.72± 1.13	7.19± 0.91*	0.458	7.35± 1.09	7.00± 1.00	-0.334
BOMBT	6.04± 0.69	6.55± 0.69*†	0.739	6.38± 0.71	6.55± 0.72*	0.237
Bent arm hang	30.03±13.67	37.53± 14.14*†	0.540	29.75± 14.47	31.23±13.37*	0.106
Push ups	10.90± 2.50	15.03± 3.07*†	1.475	11.53± 3.27	13.80± 3.42*	0.678
Sit ups	30.00± 5.86	34.13± 6.65*	0.658	32.10± 6.51	34.86± 5.25*	0.466

* Significantly different from initial, p<.05; † Significantly different from control, p<.0.5.

There were significant differences ($p<0.05$) between the initial and final testing for flexed arm hang, push ups and sit ups in both groups. However, significant interaction between groups ($p < 0.05$) was found only for bent arm hang and push ups.

DISCUSSION

The present study investigated the effects of a medicine ball training program on physical fitness in primary school children. The primary finding of this study was that regular participation in a progressive medicine ball training program produced greater improvement in physical fitness than traditional physical education lessons in primary school children after 12 weeks of training. Significant improvement was observed for the medicine ball group in both jumping tests compared to the control group. These results demonstrate that specific medicine ball training, as part of the overall physical education process, can be considered a useful tool for the improvement of jumping ability. Several studies involving children have noted significant improvements in the long jump and vertical jump, following resistance training (Falk & Mor, 1996; Lillegard, Brown, Wilson, Henderson, & Lewis, 1997; Ignjatovic, Markovic, & Radovanovic, 2012). According to Falk & Tenebaum (1996) boys and girls can increase their strength by about 30-50% during the first eight weeks of resistance training. The present results are comparable with these findings as the progressive medicine ball exercises resulted in significant gains in lower and upper body strength.

Compared with initial testing, there was a significant ($p < 0.05$) improvement in all medicine tests following the 12-week medicine ball training. Faigenbaum & Mediate (2006) stated that resistance training with medicine balls can be an effective method of conditioning for school age youth during physical education. Related studies with high school children that lasted only 6 weeks, found an increase in the medicine ball throw of 19%. (Faigenbaum & Mediate, 2006) After a similar study (Faigenbaum et al., 2007), with a combined resistance training program and medicine ball throws, the authors found an increase of 14%, and in a 12-week study (Szymanski, Szymanski, Bradford, Schade, & Pascoe, 2007), the authors found an increase of 10% in the medicine ball throws. The increases observed in our study were in line with expected increases. Additionally, Ignjatovic et al. (2012) found significantly greater gains in all medicine ball throw tests compared with the controls ($p<0.01$) in young female athletes following medicine ball training. In addition, the medicine ball group made significantly greater gains in bench and shoulder press power than the control group ($p<0.05$). One of the findings from our study was that there was a significant improvement in the bent arm hang, sit ups and push ups in both groups. However, the medicine ball group made significantly greater gains in the bent arm hang and push ups ($p<0.05$). Performance gains in the sit up test following medicine ball training were particularly notable since the training intervention included only one exercise specifically designed to enhance core strength. However, it is possible that the performance of other movements with proper exercise technique contributed to these findings.

A novel finding from the present investigation was that 10-15 min of medicine ball training performed twice per week resulted in significantly greater gains in physical fitness measures than normally achieved with standard PE in children. Since both groups participated in the same traditional PE lessons during the study period, such differences in fitness performance are likely due to the specific training adaptations that resulted from medicine ball training. However, some authors have noted significant gains in strength without significant improvements in motor performance skills (Faigenbaum, Zaichkowsky, Westcott, Micheli, & Fehlandt, 1993). Faigenbaum & Mediate (2006) explain this by the fact that programs that include exercises on weight machines are less specific than the test and may be less likely to enhance motor skills performance than programs characterized by more specific exercises that involve body weight exercises, free weights and medicine balls.

CONCLUSION

Findings from the present investigation indicate that medicine ball training instructed by qualified professionals can result in significant improvements in selected physical fitness components in children, and is a costeffective and time efficient method for promoting physical activity in school-based programs. Medicine ball training performed for 10-15 minutes resulted in significantly greater gains in physical fitness measures than gains normally achieved with traditional physical education. Our findings, combined with positive feedback from physical education teachers, indicated that medicine ball training can be an effective and enjoyable part of promoting physical fitness in primary school children. Future studies should focus on potential differences in training intensity as well as the long-term effects of medicine ball training during childhood on physical activity habits and health-related conditions in later life.

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EFEKTI TRENINGA SA MEDICINKOM NA FIZIČKI FITNES KOD ŠKOLSKE DECE

Medicinka može da bude efikasno sredstvo za poboljšanje mišićne snage, izdržljivosti i funkcionalnog fitnesa. Cilj ovog istraživanja je bio da se utvrde efekti treninga sa medicinkom na fizički fitness kod dece. Ukupno 60 (26 djevojčica) učenika osnovnih škola uzrasta od 10-12 godina dobrovoljno je učestvovalo u ovoj studiji. Fizički fitnes dece je procenjen sledećim testovima: skok u dalj iz mesta, vertikalni skok, vis u zgibu, podizanje trupa, sklekovi, i testovi bacanja medicinke. Eksperimentalna grupa je imala dva puta nedeljno trening sa medicinkom u toku 12 nedelja, pod kontrolisanim uslovima u školi. U poređenju sa inicijalnim testiranjem, došlo je do značajnog (p <0,05) poboljšanja u oba testa skočnosti. Kod testova bacanja medicinke ANOVA je pokazala statistički značajne razlike između grupa pre i nakon trening programa (p <0,05) kod testa bacanje medicinke iza glave. Postoje značajne razlike (p<0,05) između inicijalnog i finalnog testiranja kod visa u zgibu, sklekova i podizanja trupa kod obe grupe. Nalazi iz ove studije pokazuju da trening sa medicinkom uz instrukcije od kvalifikovanih stručnjaka može dovesti do značajnih poboljšanja u odabranim komponentima fizičkog fitnesa kod školske dece, i to uz minimalne troškove kao vrlo efikasan metod za promovisanje fizičke aktivnosti u školskim programima.

Ključne reči: *vežbanje, fizičko vaspitanje, uticaj, fitnes*